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Marbled Murrelet Population Monitoring Program for Northwest Forest Plan Effectiveness Monitoring - DRAFT -

MONITORING PROGRAM

Marbled murrelet (*Brachyramphus marmoratus)* populations are best assessed at sea due to the cryptic nature of the species' nesting habitat in forest canopies throughout much of its range. This Marbled Murrelet Population Monitoring Program (Program) is designed to assess the population associated with the Northwest Forest Plan as required in the Record of Decision and subsequent court cases. Overall guidance for monitoring the Forest Plan comes from Mulder et al. (1999), who developed a large-scale monitoring strategy. Tiering from that document, Madsen et al. (1999) developed a "Marbled Murrelet Effectiveness Monitoring Plan for the Northwest Forest Plan." Additional monitoring guidance comes from the U.S. Fish and Wildlife Service Marbled Murrelet Recovery Plan (1997). This Program consists of a sampling design, standardized survey protocols, and coordinated data collection for marbled murrelets in the coastal waters of California, Oregon and Washington, including Puget Sound. Table 1 provides a summary of the Program.

SAMPLING DESIGN

Spatial Target Population

The Northern boundary is the Canadian border and the Southern boundary is approximately San Francisco Bay. (Note that Marbled Murrelet Conservation Zone 6 as identified in the Recovery Plan (USFWS 1997), is outside the Forest Plan area, however, this zone could be sampled according to this Program.)

The near shore boundary is roughly the shoreline, surf line, or kelp line that equates to safely navigable waters. This information will be gathered for each primary sampling unit (PSU).

The offshore boundaries vary in different conservation zones and portions of zones (Figures 1-8). These distances are based on available data about murrelet offshore distributions. Our rationale also includes bathymetry, our understanding of the associated distributions of prey species, and consequently, the foraging opportunities for murrelets. We do not foresee a consistent long term increase of birds offshore of the outer boundary. However, if evidence starts to suggest this may be happening, it will likely necessitate adding another stratum further offshore.

Temporal Target Population

Mid-May through middle or late July is the time of year when breeding birds at sea are likely to be associated with inland nesting habitat in the Forest Plan area. Sampling for the purposes of monitoring the population will occur during this time frame, however, it may be extended later into the season depending on future decisions about whether and how to incorporate productivity into the Program.

Stratification

The Recovery Plan (USFWS 1997) outlines six conservation zones, five of which fall within the Forest Plan area. Each zone represents a stratum. This sampling design will obtain separate population estimates and trends for each zone. The Recovery Plan suggests murrelets may have reached recovery status when populations within four of six zones have stable or increasing numbers. Within each zone, researchers have identified general geographic areas of different densities of murrelets along the coast. These areas are geographic strata within the zones. Some level of sampling will happen within each geographic stratum. Lower density strata will receive less sampling effort.

Primary Sampling Units

Spatial definition of a primary sampling unit (PSU). A PSU is a roughly rectangular area the length of which is about 20 km of coast line and the width of which is the distance between the inshore and offshore boundaries (Figure 9). The width varies in different areas by zone and stratum (Figures 1-8). The PSUs are configured to meet end to end without any gaps along shore. Each PSU represents a cluster consisting of two subunits, one near shore and one offshore (divided by the 'center line'). Once defined, the PSU boundaries and locations will be fixed for the duration of the Program.

The inshore boundary adjacent to the coast will be recorded for each PSU. The location of this boundary depends on the physical features of the shore line that affect navigation. In some instances, these physical features are permanent obstructions such as submerged rocks or islands. In other cases, these features are less permanent such as kelp beds that shrink or expand depending on storm activities or the presence or absence of sea otters. Navigation is also affected by tidal fluctuations. Some areas that can be surveyed during high tides may be inaccessible during low tides.

Temporal definition of PSU. Approximately a half day's effort to avoid splitting a primary sampling unit over two days (allowing for weather and mechanical difficulties). However, it is possible to complete more than one PSU in a day.

Method of selecting PSUs. PSUs will be selected randomly without replacement and samples will be spread over the field season (time). In high density geographic strata, some PSUs will be sampled numerous times throughout the field season. In low density areas PSUs will be sampled once or not selected. While the selection of PSUs will be random, sampling is subject to logistic constraints such as the location of ports. In order to alleviate the possibility of having one PSU

Sample size per zone. Each conservation zone will have a sample size of approximately 30 at a minimum; more if weather, logistics, etc. permits.

Method of subsampling PSUs. Parallel and zigzag transects will be used to subsample the PSUs. In the near shore subunit, parallel transects will be used and zigzag transects will generally be used in the offshore subunit (Figure 9). Transects will be placed to avoid overlapping sampling effort within the two subunits.

Within the near shore subunit, the entire length (~20km) of the PSU will be divided into four 5-km transects. The inshore subunit will be divided into four bins parallel to shore. One transect will be randomly chosen from each bin ensuring that transects are spread out spatially from shore (Figure 10). These distances will be chosen in increments of 100 meters beginning at 50 meters from the inshore boundary (which equates to the navigable waters). Researchers will randomly choose one inshore parallel transect from each bin without replacement.

Within the offshore subunit, a kind of 'zigzag' transect will traverse the entire width of the subunit (distance from shore) and a portion of the length of the PSU (Figure 11). The transect will be more of a 'zig', and will always go to the right when looking from shore (but can be traveled in either direction). The layout of the transect will be determined from a selection point chosen from random points at 100 m increments along the 'left' side or along the center line of the PSU. A transect layout along the left or right side of the PSU will be divided into two segments so that the offshore and along shore distances receive an equal amount of coverage without duplication (Figure 11a and c).

The length of the transect in the offshore subunit is based on information about the area of the PSU and general densities within a geographic stratum.

Each PSU consists of two subunits labeled near shore and offshore with areas (in km^2) a_1 and a_2, respectively. If we can assume that the number of birds observed in each collection of subunit transects follows a Poisson distribution with mean densities λ_1 and λ_2 (in birds per km^2), then the optimal ratio of near-shore to far-shore transect length is given by:

$$r = \frac{a_1}{a_2} \cdot \sqrt{\frac{\lambda_1}{\lambda_2}}$$

which is just the product of the area ratio and the square-root of the density ratio.

The exception to having zigzag transects in the offshore subunit will be around the convoluted shorelines and islands of Puget Sound where researchers will use parallel transects.

The density estimates derived from these subsampling methods will be weighted according to the area of the subunit then combined for one density estimate for the PSU at the time it is sampled. Each sample is then combined with the other samples within the conservation zone for a population estimate for the entire zone. Data from the first year will be used to estimate variability associated with this sampling regime.

SURVEY METHODS

Distance Sampling

This transect method (Buckland et al., 1993) will be used to obtain densities (number of murrelets per unit area), and ultimately, population estimates. This method accounts for the fact that our ability to detect objects off a transect is generally less at greater distances. Different ‘distances’ of objects are gathered from the transect and those data are used to develop detection histograms. The Distance Program uses the histograms to develop detection functions which are then used to "fill in" the data points which were missed presumably because they were further from the transect.

Observer Methods

All monitoring surveys will have two observers in addition to a boat operator. Each observer will search for birds in a 90° arc on either side of the boat starting from the bow. It is important when using the Distance Sampling method to observe all birds on or close to the transect line. Observers will scan continually, slowing their pace a little at the bow of the boat and speeding up a little abeam of the boat. A complete scan of 90° should take about 5-7 seconds. Observers will estimate the perpendicular distance of murrelets from the transect line. Binoculars are used for species verification but not for sighting birds. Observers will record information into a tape recorder for subsequent transcription to data sheets. (Attachment A. Data sheet is still under construction.)

Boat Size and Speed

There are size differences among the boats. The height of the observer is likely to be the most important aspect of this and will be a field in the data sheets. The boat speed is approximately 8-12 knots. When viewing conditions are good, boats can travel closer to 10-12 knots without missing birds, however, we recommend boat speed of 8-10 knots as viewing conditions deteriorate. Observers should work with boat operators to obtain optimal and consistent viewing conditions between 8-12 knots.

Viewing Conditions

If visibility drops below 100m due to fog, mist, etc. surveys should stop. Wavelets occur when winds create white caps. Too many wavelets cause confusing viewing conditions. When wavelets are closer than 50m, surveys should stop.

Training

Observers will be trained and tested for such parameters as percentage of birds correctly identified, distance estimates within certain acceptable levels, percentage of birds missed, etc. For example, observers can be tested to be within a certain percentage of true perpendicular distances 90% of the time. This can be accomplished using a variety of methods. For distance training, buoys can be attached to tape measures or lines and deployed at known distances from behind the boat. For perpendicular distances, the boat can run a series of transects through a field of fixed objects (e.g., crab pot buoys). Observers are then trained and tested using a laser range finder when the boat draws perpendicular to the object off the transect line. This is best done with fixed objects.

Observer variability
One of the largest sources of variability may be between observers. We hope that a rigorous training program will help reduce this problem. Also, we encourage interchanging crew members between areas to spread out the effects of observer variability; however, this is not intended to incur significant additional travel costs.

Time of Day
Due to the fact the winds pick up in the afternoon in most areas, most surveys are done between early morning and early afternoon. Time of day will also be recorded as a field.

ANALYSIS/DATA MANAGEMENT
Distance Program
Martin Raphael is assembling a template of Distance steps for the group to review and share with Jeff Laake. He will share that with the group July 1, 2000. For density estimates, we will use the actual distance traveled on a transect weighted by the area of the PSU. We will obtain a detection function and density estimate per geographic stratum. For areas with small sample sizes, we will use the detection functions of an area nearby.

Analysis
A bootstrap statistical method will be used to analyze the variation from the PSUs. Marty Raphael and Tim Max will work with Jeff Laake to determine whether the Distance Program software will do this automatically. This will be shared with the group by July 31, 2000.

Level of Precision
The statisticians will estimate our precision with this design and further refine it after a year of sampling has been completed. Information we gain after the first year of sampling will tell us whether we need to increase or decrease the sample size in future years.

Data Management
Ken Ostrom will help facilitate the consolidation of data for a larger analysis. A set of common data fields will be gathered for monitoring purposes. (Attachment A)

PRODUCTIVITY
This topic needs further discussion.

Table 1. Summary Table of Sampling Design

Researcher and Recovery Zone	MR/CT (1)	CT (2)	CS (3)	CS/CJ (4)	CS/CJ (5)	(6)
Target Population	Entire Zone 1	Entire Zone 2	Entire Zone 3	Entire Zone 4	Entire Zone 5	Entire Zone 6
Geographic Strata (see Figures 1-8)	1. Strait of Juan de Fuca 2. San Juan Islands and selected portions of Puget Sound 3. The remainder of San Juan Islands and Puget Sound	1. WA North Coast 2. WA South Coast 3. Grays Harbor, Willapa Bay and Columbia River	1. North portion of Zone 2. South portion of Zone	Entire Zone	1. North half of Zone 2. South half of Zone	1. Half Moon Bay to Watsonville 2. Remainder of zone 6
Primary Sampling Unit (PSU) (see Figure 9)	~20 km section of coast line with inshore and offshore subunits	~20 km section of coast line with inshore and offshore subunits	~20 km section of coast line with inshore and offshore subunits	~20 km section of coast line with inshore and offshore subunits	~20 km section of coast line with inshore and offshore subunits	~20 km section of coast line with inshore and offshore subunits
PSU Inshore/Offshore Subunits by Geographic Stratum	1. Navigable waters-1500m/1500-5000m 2. Navigable waters-500m/500-2000m 3. Navigable waters-500m/500-2000m	1. Navigable waters-1500m/1500-5000m 2. Navigable waters-1500m/1500-8000m	1. Navigable waters-1500m/1500-5000m 2. Navigable waters-1500m/1500-5000m	Navigable waters-1500 m/1500-3000m	1. Navigable waters-1500 m/1500-3000m 2. Navigable waters-1500 m/1500-3000m	1. Navigable waters-1500 m/1500-3000m 2. Navigable waters-1500 m/1500-3000m
PSU Selection	Random selection without replacement within each geographic stratum and spread over time and space to the maximum extent feasible logistically	Random selection without replacement within each geographic stratum and spread over time and space to the maximum extent feasible logistically	Random selection without replacement within each geographic stratum and spread over time and space to the maximum extent feasible logistically	Random selection without replacement within each geographic stratum and spread over time and space to the maximum extent feasible logistically	Random selection without replacement within each geographic stratum and spread over time and space to the maximum extent feasible logistically	Random selection without replacement within each geographic stratum and spread over time and space to the maximum extent feasible logistically

Researcher and Recovery Zone	MR/CT (1)	CT (2)	CS (3)	CS/CJ (4)	CS/CJ (5)	(6)
Total PSUs (per Geographic Stratum)	~111 Stratum 1- 9 Stratum 2 - 42 Stratum 3 - 47	17 Stratum 1 - 8 Stratum 2 - 6 Stratum 3 - 3	17 Stratum 1 - 7 Stratum 2 - 10	22	16 Stratum 1 - 7 Stratum 2 - 9	12 Stratum 1 - 6 Stratum 2 - 6
Sample Size of PSUs per Season (by Geographic Stratum)	~30 Stratum 1 - 5 Stratum 2 - 20 Stratum 3 - 5	~33 Stratum 1 - 24 Stratum 2 - 6 Stratum 3 - 3	~30 Stratum 1 - 10 Stratum 2 - 20	~30	~30 Stratum 1 - 25 Stratum 2 - 5	~30 Stratum 1 - 25 Stratum 2 - 5
PSU Subsampling	Four 5-Km parallel transects in inshore subunit, parallel and zigzag offshore	Four 5-Km parallel transects in inshore subunit, zigzag offshore	Four 5-Km parallel transects in inshore subunit, zigzag offshore	Four 5-Km parallel transects in inshore subunit, zigzag offshore	Four 5-Km parallel transects in inshore subunit, zigzag offshore	Four 5-Km parallel transects in inshore subunit, zigzag offshore
Time of Year	Mid-May to mid-July	Mid-May to mid-July	Mid-May to end of July	Mid-May to end of July	Mid-May to end of July	Mid-May to end of July

MR = Martin Raphael, FS PNW
CT = Chris Thompson, WDFW
CS = Craig Strong, Crescent Coastal Research
CJ = CJ Ralph, FS PSW

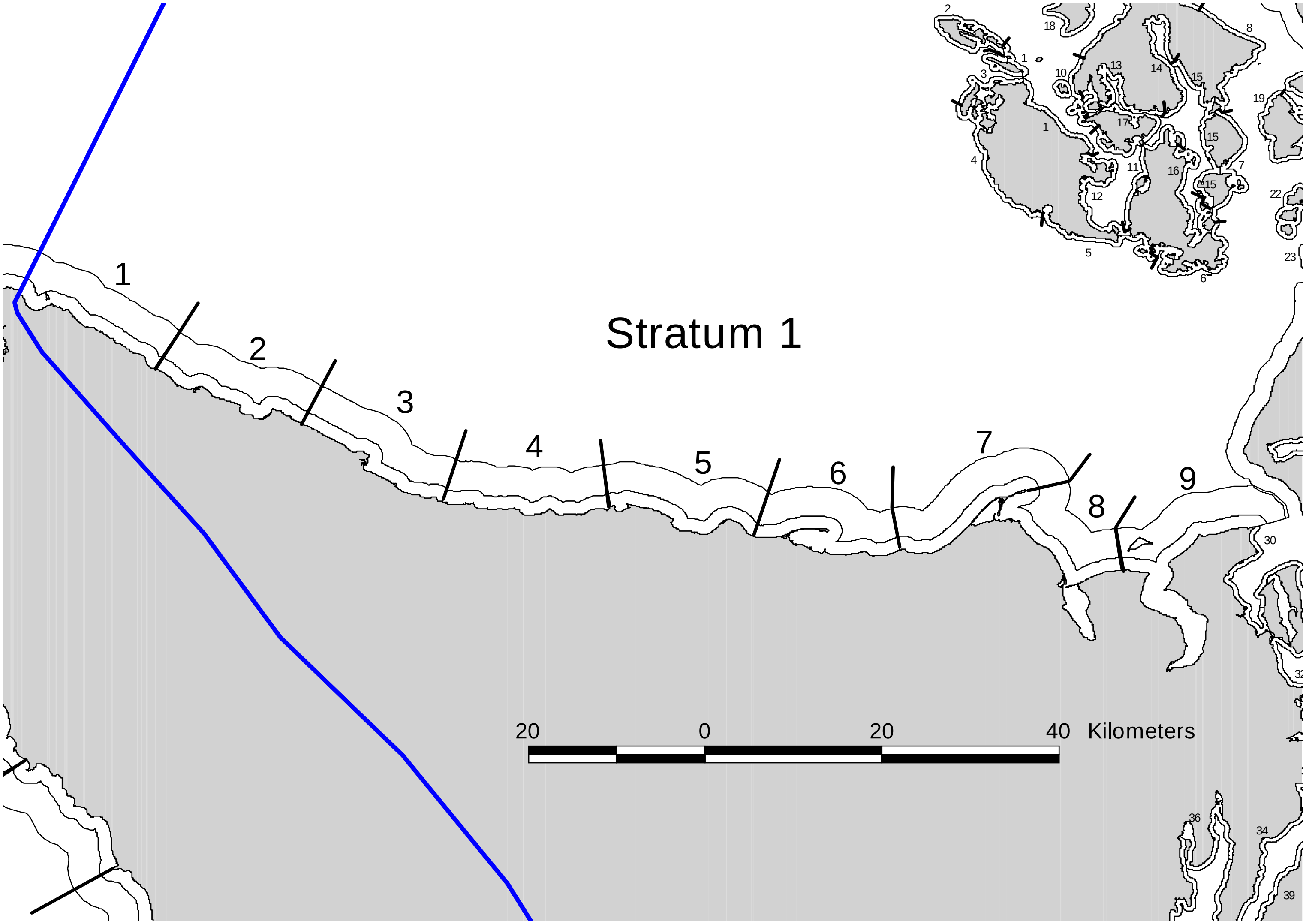

Figure 1. Zone 1, Stratum 1 Primary Sample Units.

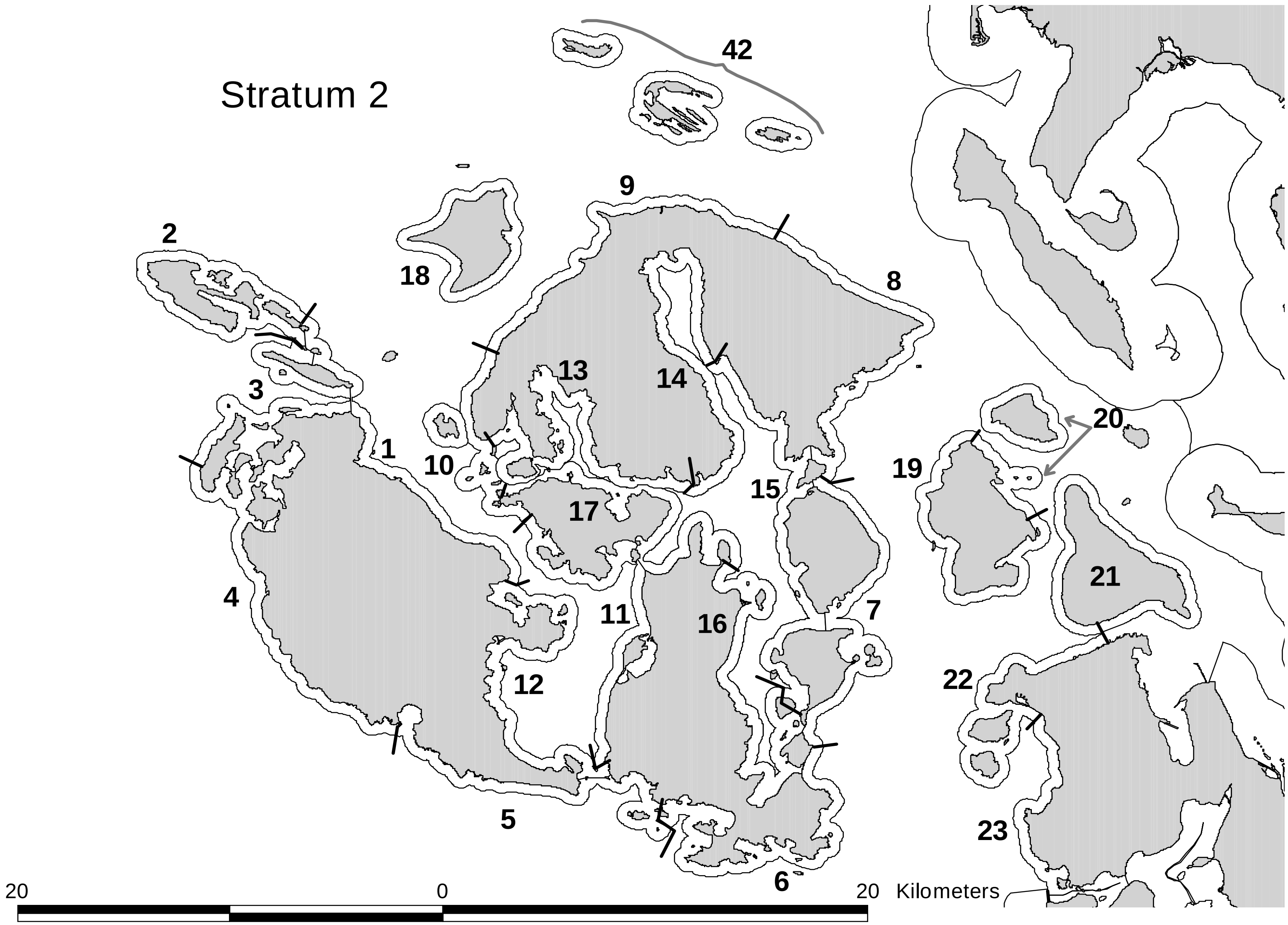

Figure 2. Zone 1, Stratum 2 North (San Juan Islands) Primary Sample Units.

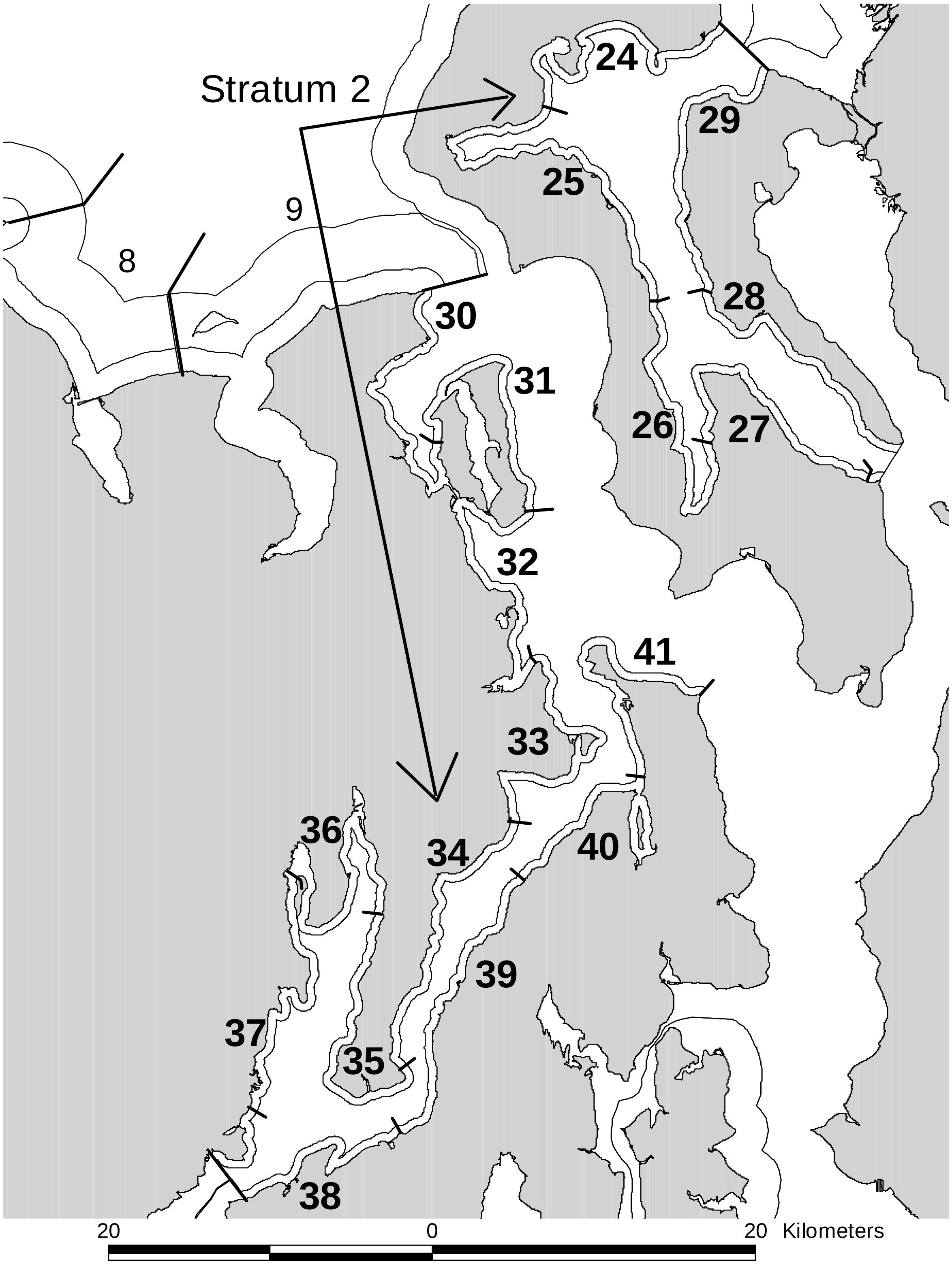

Figure 3. Zone 1, Stratum 2 South (Saratoga Passage and Hood Canal) Primary Sample Units.

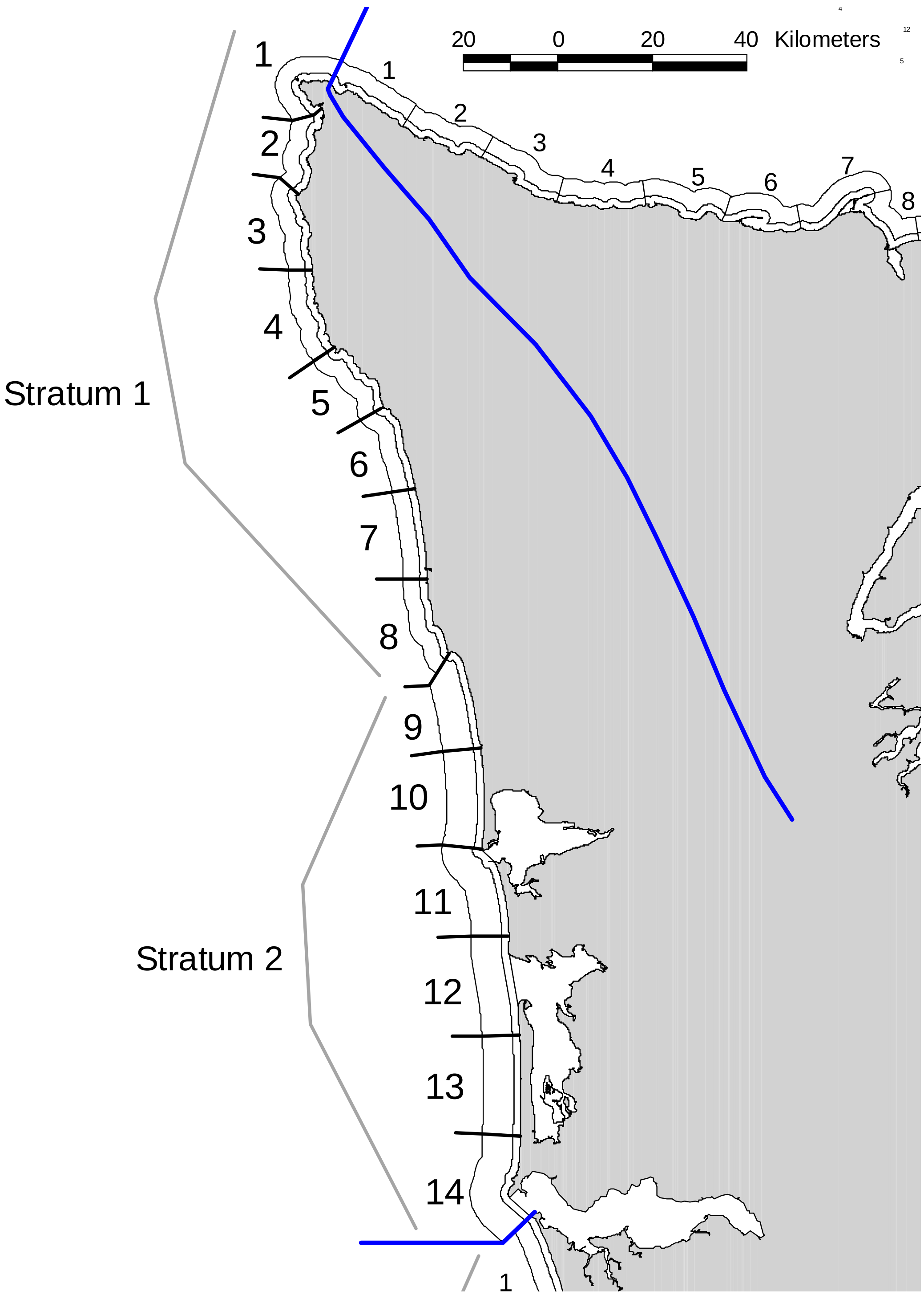

Figure 4. Zone 2 Primary Sample Units.

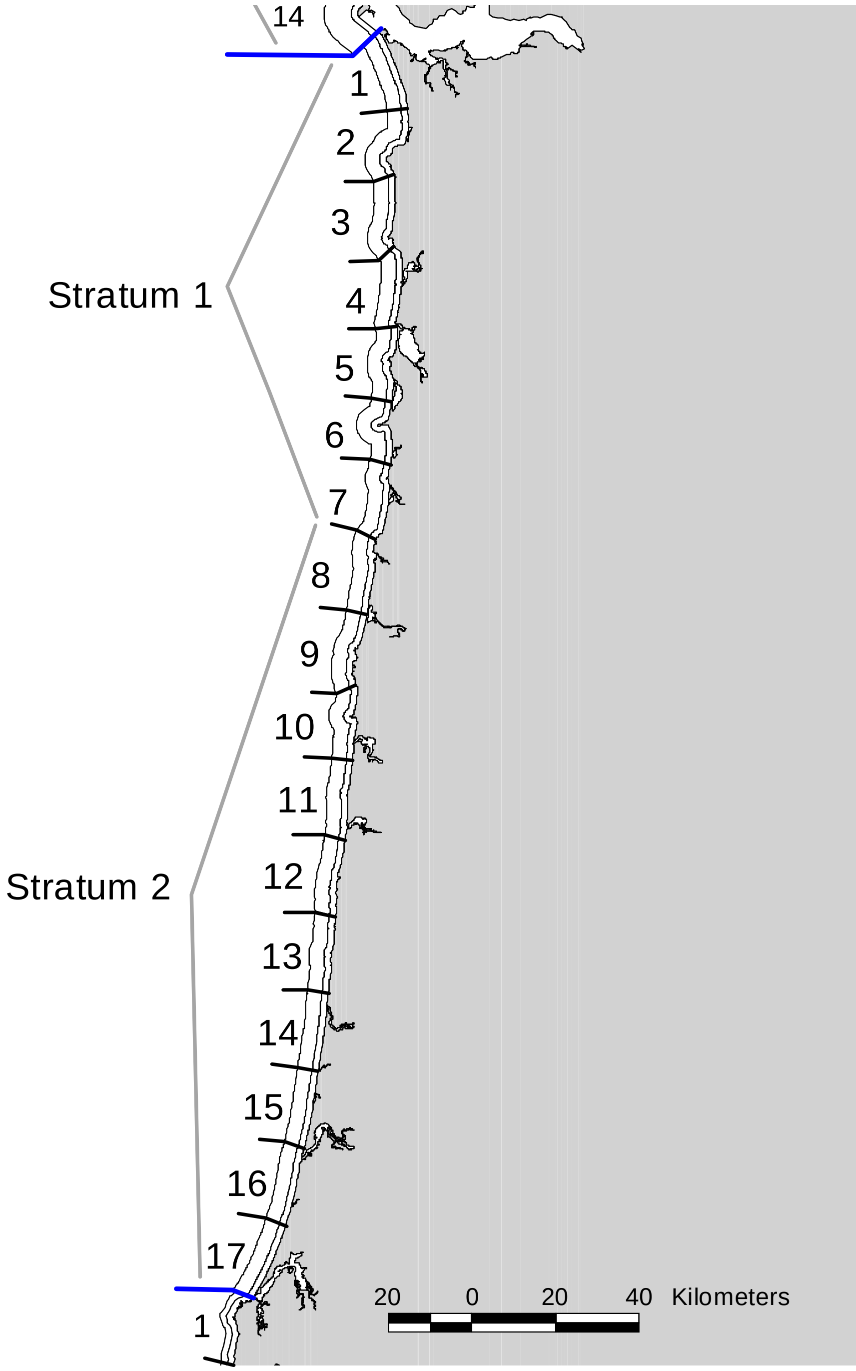

Figure 5. Zone 3 Primary Sample Units.

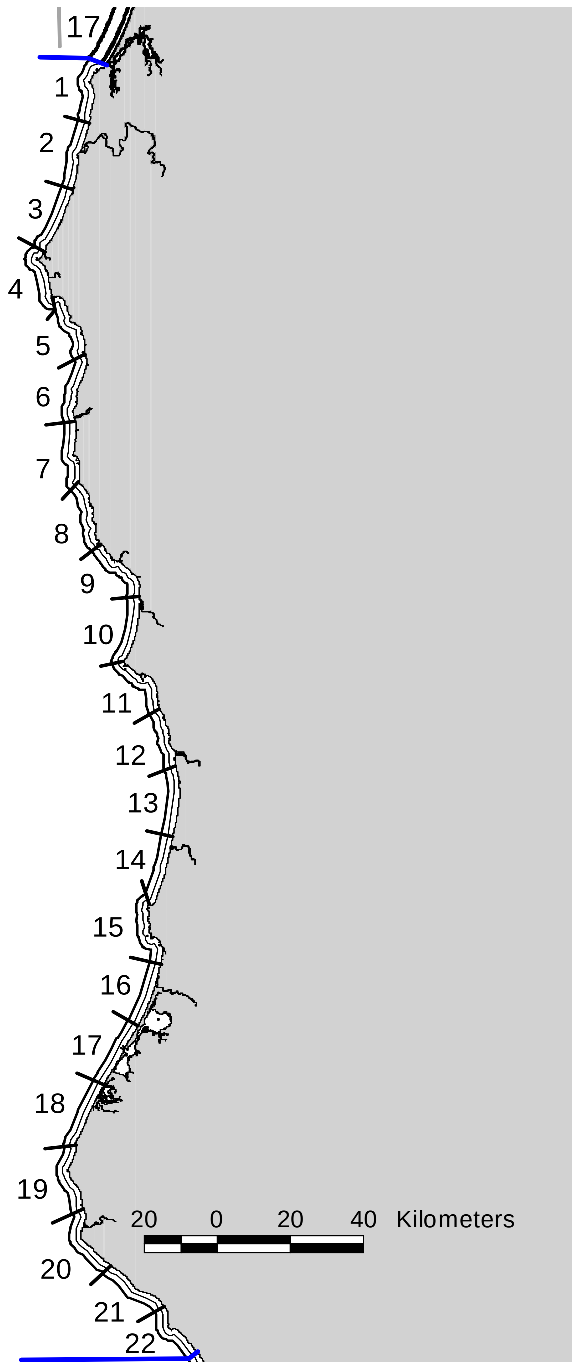

Figure 6. Zone 4 Primary Sample Units.

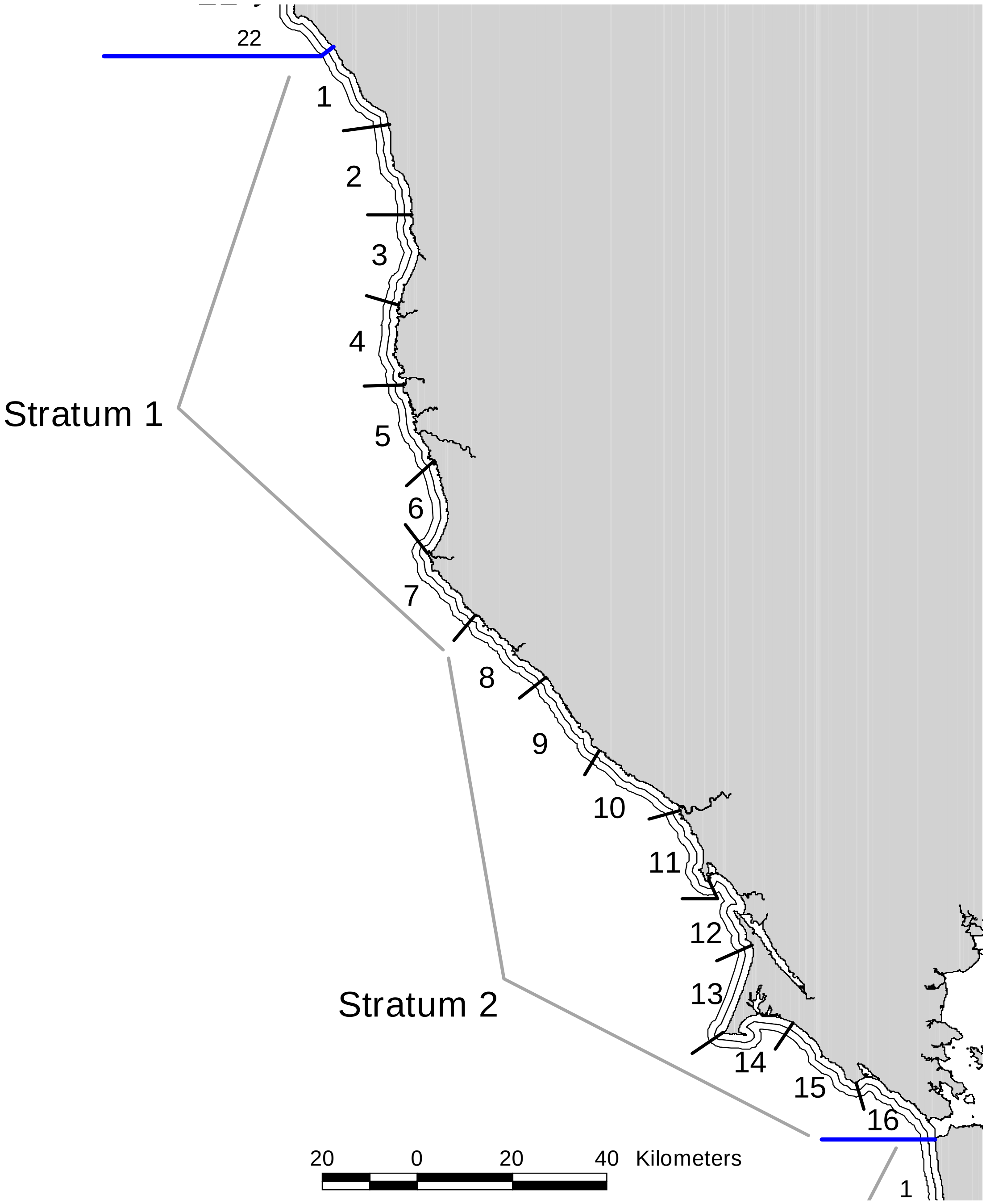

Figure 7. Zone 5 Primary Sample Units.

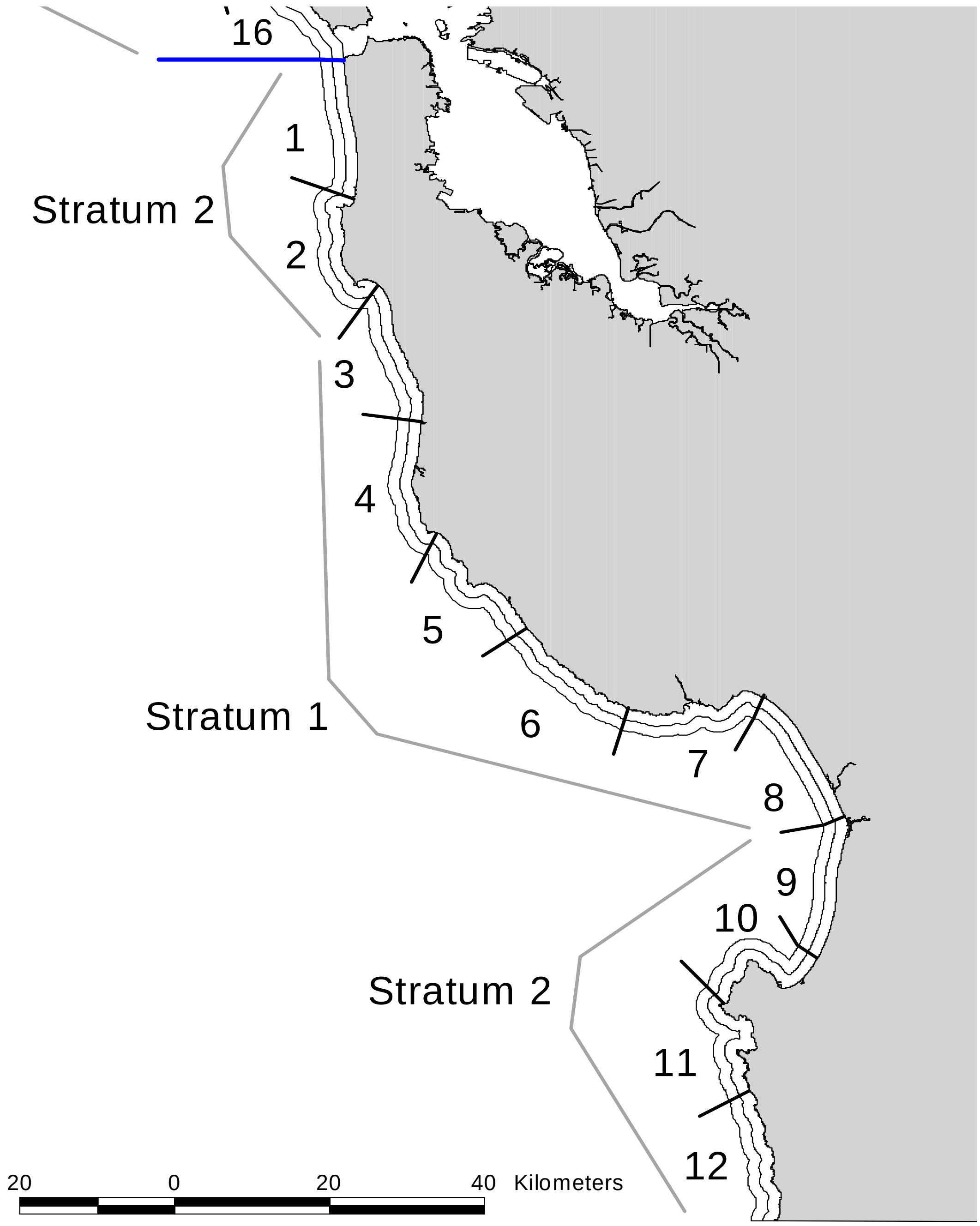

Figure 8. Zone 6 Primary Sample Units.

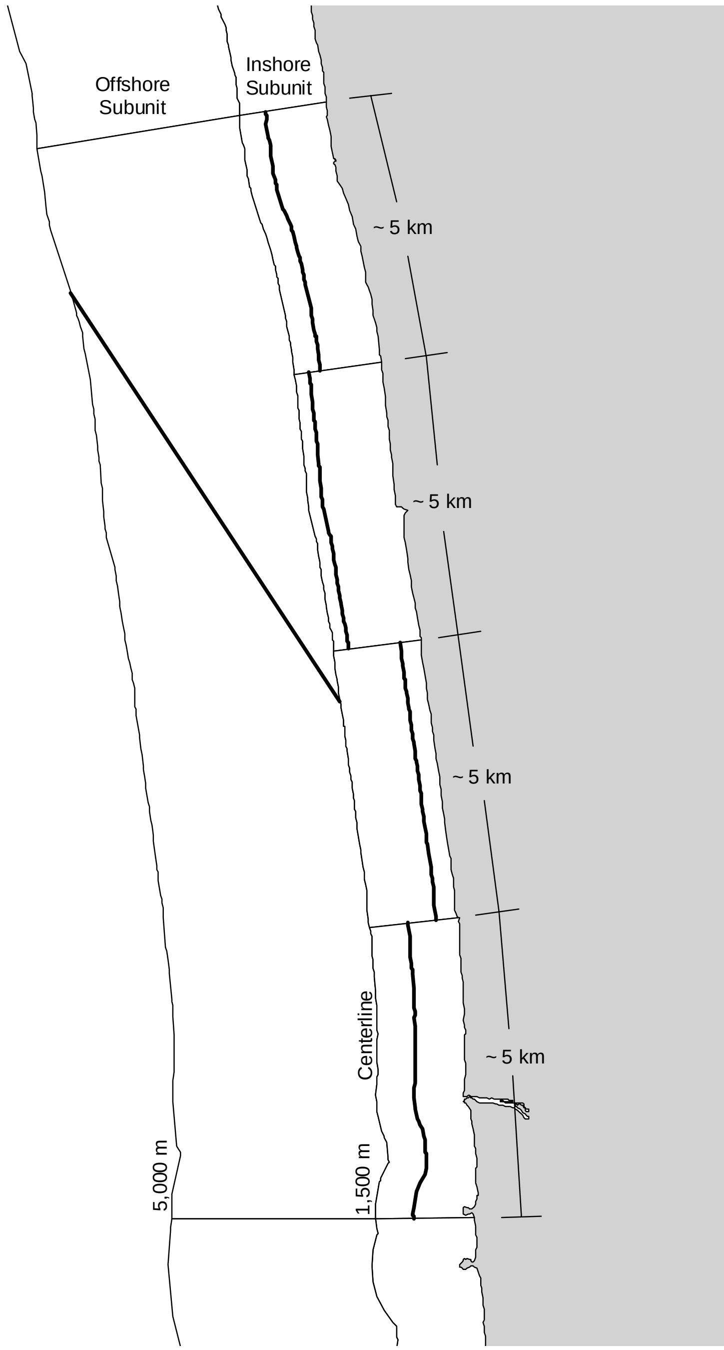

Figure 9. Example of Sample Unit Subsampling.

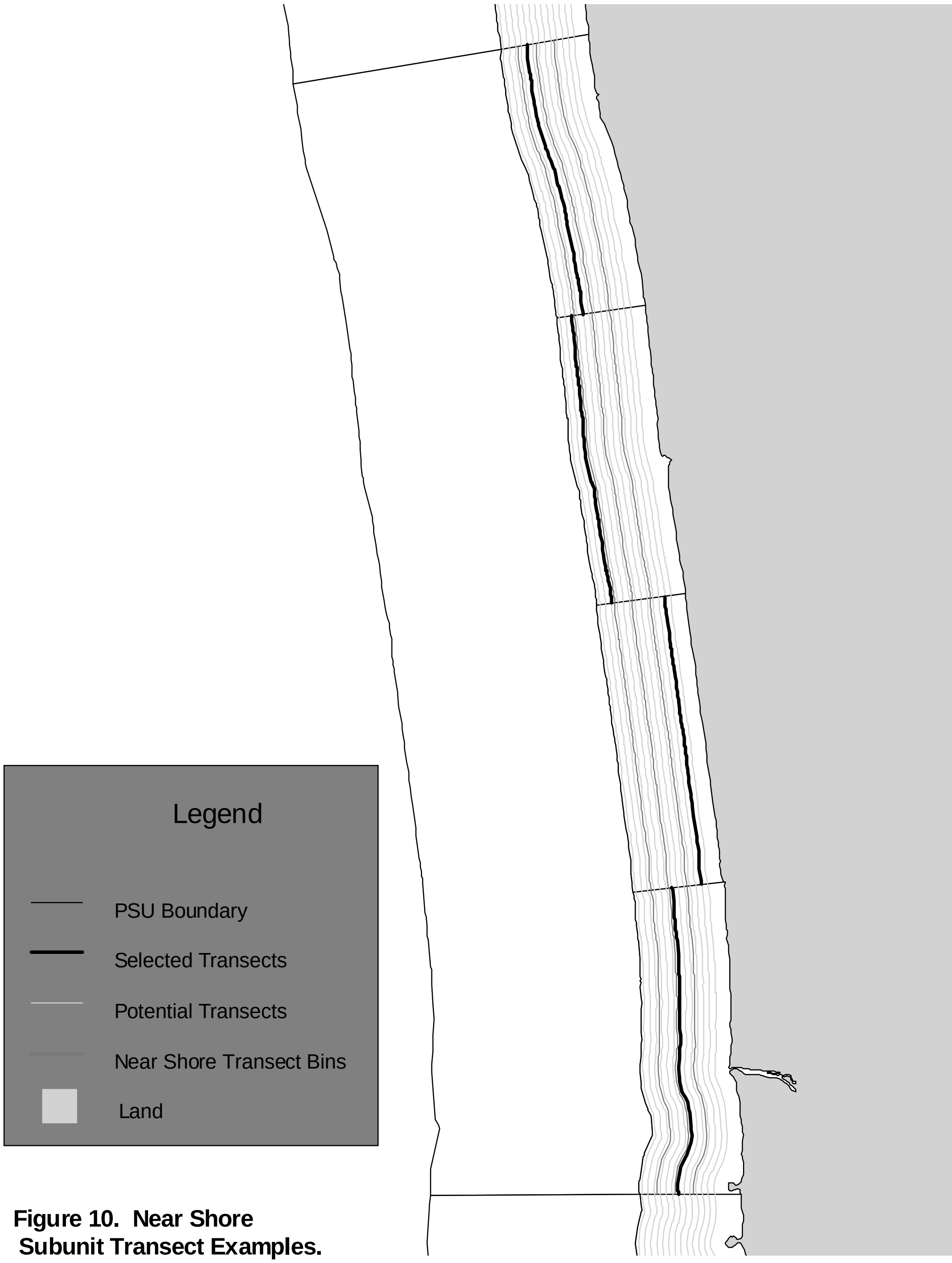

Figure 10. Near Shore Subunit Transect Examples.

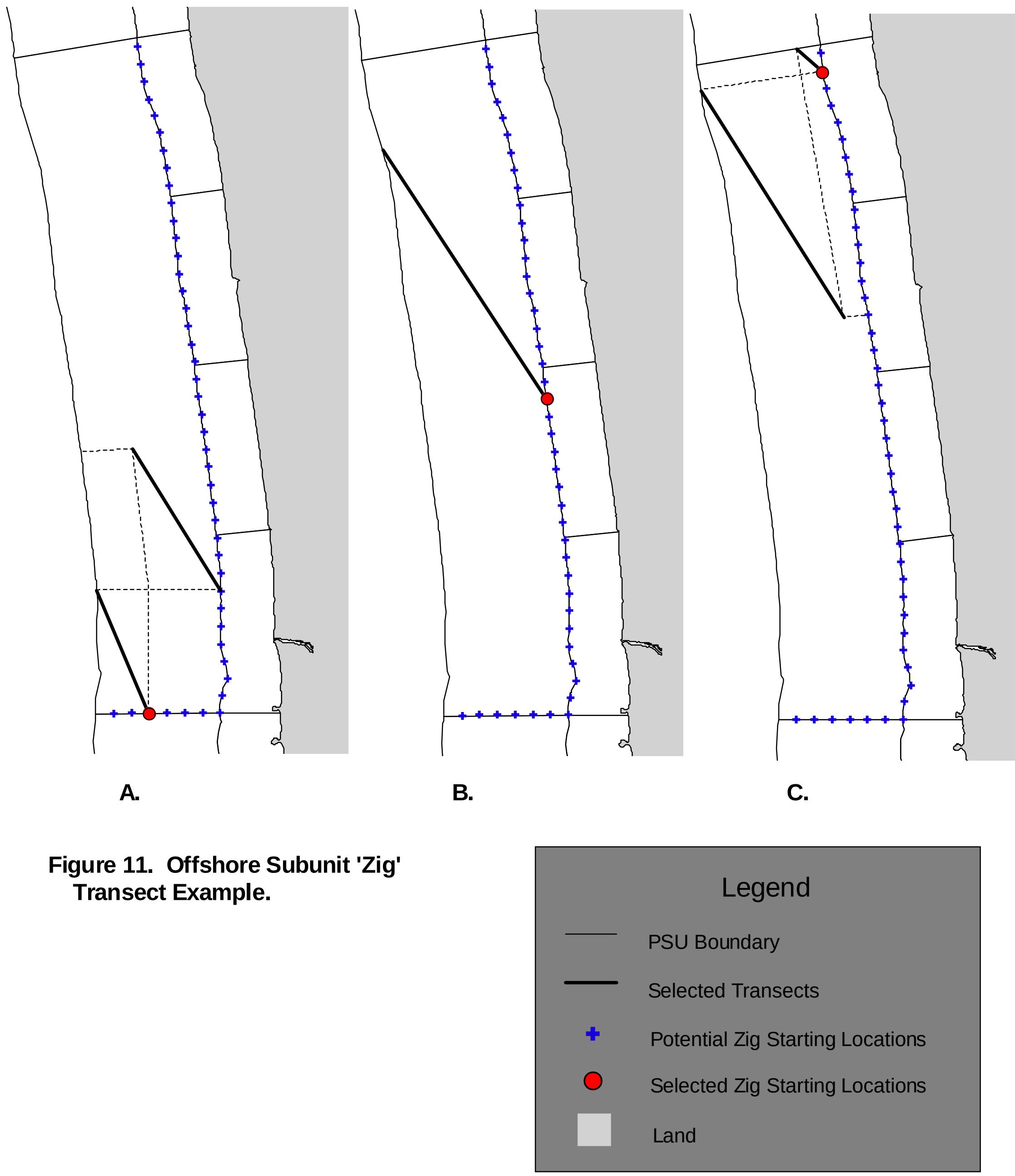

Figure 11. Offshore Subunit 'Zig' Transect Example.

Attachment A

OFFSHORE MARBLED MURRELET SURVEY FORM
--INSTRUCTIONS–

Header

Zone	1 digit
Strata	1 digit
PSU	2 digits
Vessel	first 4 letters of boat name
Observer Height	eye height **(m)** above water where observer is standing
Skipper	initials of boat navigator
Observer 1	3 letters initials of observer
Observer 2	3 letters initials of observer
Date	6 digits date (mo-dy-yr)
Notes	any pertinent info specific to survey. Example inshore obstructions to surveys.

Main Form

Subunit	1 letter, N or O, for Near Shore or Offshore
Distance	4 digits **(m)** for parallel transect distance from shore. Example 1250 m
Segment	1 letter A, B, C, or D for segment along shore
Seg length	2 digits for actual length traveled on parallel transect (**km** to nearest 0.1km). Example 5.2 km
Z Start A	3 digit code **(m)** for zigzag starting point along shore. This is a distance beginning from left side of the PSU (looking out from shore). Example 120 m
Z Start O	4 digit code **(m)** for zigzag starting point offshore. Example 1500 m
Z End A	3 digit code **(m)** for zigzag ending point along shore
Z End O	4 digit code **(m)** for zigzag ending point offshore
Z Length	3 digits for actual length traveled (**km** to nearest 0.1km). Example 15.2 km.
Time	4 digit code, military time. Taken at start of every segment and to show breaks (murrelets opt)
Depth	4 digits bottom depth **(ft)**. Read from depth sonar (fish finder) at beginning of every segment and at murrelets
Clouds	% cloud cover; ocular estimate
Precip	1 letter code for precipitation (N=none, D=drizzle, S=Shower, L=light rain, R=steady rain, F=fog)
Visibility	4 digit or 1 letter horizontal distance of clear visibility **(m)**; 'U' for unlimited
Glare	3 digits for % glare or reflection that is hindering view of the water.
Swell Dir	1 to 3 letter code for direction of swells (N=north, NNW=north northwest, etc.)
Swell Ht	height **(m)** of average swell from crest to trough (to nearest 0.1 m)
Swell Time	average time (sec) between swells (crest to crest or trough to trough)
Wave Dir	1 to 3 letter code for direction of wind waves or wavelets (N=north, NW=northwest, etc.)
Wave Ht	height **(cm)** of average wavelet
Wind Speed	2 digits **(mph)** measured from anemometer
Beaufort Scale	1 digit code for Beaufort Sea conditions
Wind Dir	1 to 3 letter code for wind direction
White Caps	average distance **(m)** between whitecaps on different swells
P,S,B	1 letter code for side of boat of detection (Port, Starboard, Bow)
Species	4 letter species code for observation based on common name. First 2 letters of first word, first 2 letters of last word, or first letters of each word in common name. Example: White-winged Scoter=WWSC. For those identified only to genus, use first 4 letters of common generic name. Example: TERN or LOON
Number	group size of detection
Distance	perpendicular distance **(m)** of bird from transect line (use center of a group of birds)
Behavior	1-letter code for behavior of murrelets S=swimming F=flying T=taking flight H=holding fish

D=foraging dive A=avoidance dive   V=vocalization

Plumage Class	number of murrelets from total group in each of 7 plumage classes recorded as definite or probable 1= brown bird, very little to no molt, entirely in alternate plumage 2= obvious body and/or flight feather molt but >50% alternate (brown) 3= <50% brown but still distinguishable from juvenile by some brown on back, breast, and neck and/or presence of flight feather molt 4= black and white bird (basic plumage) - known adult 5= black and white bird but confirmed HY 6= unknown black and white bird 7= unknown
Plumage Notes	additional information on plumage - as much detail is needed to support classification

Note: Page numbers of the forms are not variables, but should be entered as follows: 1 of 2, 2 of 2, etc.

Literature Cited

Buckland, S., D. Anderson, K. Burnham, and J. Laake. 1993. Distance sampling: Estimating abundance of biological populations. Chapman and Hall. London. 446pp.

Madsen, S., D. Evans, T. Hamer, P. Henson, S. Miller, S. Nelson, D. Roby, and M. Stapanian. 1999. Marbled murrelet effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-439. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51pp.

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U.S. Fish and Wildlife Service. 1997. Recovery plan for the threatened marbled murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, OR. 203pp.